EFFECT OF ALKALI TREATMENT CONDITIONS OPTIMIZATION ON KENAF FIBER POLYESTER COMPOSITE CHARACTERIZATION

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For my beloved mother PATIMAH BINTI SAHDAN,
my father HASHIM BIN MARMAN, my dear wife SITI AISYAH BTE MISRAN,
my mother in law KHATIJAH BTE NORUDIN and my little hero
MUHAMMAD HARITH NAUFAL

"THANK YOU for your endless support"

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ABSTRACT

This study was conducted to evaluate the alkali treatment conditions optimization impact on kenaf fiber and its short random oriented kenaf fiber reinforced polyester matrix composite mechanical properties characterization. The selected treatment conditions are alkali solution concentration (2% w/v ~ 10% w/v), immersion duration (30 minute ~ 480 minute) and immersion temperature (room temperature ~ 100^{o}C). Two types of experimental design approach were used in this work. It was three factors at three levels full factorial design for evaluating the kenaf fiber mechanical properties characterization and Response Surface Methodology (RSM) for determining the optimum alkali treatment conditions on kenaf polyester composite mechanical properties characterization. As the outcome of this study, the significant main-and-interaction effect of alkali treatment condition for kenaf fiber was determined. Furthermore, the correlation between optimum alkali treatment conditions with enhancement of kenaf fiber polyester matrix mechanical properties was suggested in the form of regression model. Based on the results, several regression models have been constructed according to Analysis of Variance and the regression model. Confirmation tests have been conducted towards selected predicted regression model. The confirmation test results shows good agreement with the proposed regression model. Finally, the outcome with a reliable database for optimum alkali treatment condition setting presented through this dissertation is expected to enhance insight regarding the knowledge of significant parameters in alkali treatment optimization that is extensively used in natural fiber surface treatment.

ABSTRAK

Kajian ini dilakukan untuk menilai kesan pengoptimuman parameter rawatan alkali ke atas ciri-ciri mekanikal gentian kenaf dan juga kompositnya yang diperbuat dari gentian kenaf pendek dan berterabur secara rawak yang dicampur poliester resin. Parameter untuk rawatan alkali adalah kepekatan larutan alkali (2% w/v ~ 10% w/v), tempoh rendaman (30 minit ~ 480 minit) dan suhu rendaman (suhu bilik ~ 100^{o}C). Dua jenis kaedah rekabentuk eksperimen telah digunakan. Ia adalah kaedah rekabentuk faktorial penuh menggunakan tiga faktor di tiga tahap untuk menganalisa sifat mekanikal gentian kenaf dan kaedah Response Surface Methodology (RSM) untuk mengenalpasti sifat mekanikal komposit daripada kenaf dan poliester pada ketetapan rawatan alkali yang optimum. Melalui hasil kajian, faktor utama dan perkaitan diantara faktor semasa rawatan alkali untuk gentian kenaf telah dapat ditentukan. Selain itu, korelasi antara parameter rawatan alkali yang optimum dan mampu meningkatkan sifat mekanikal komposit berasaskan gentian kenaf dan poliester telah diterjemahkan dalam bentuk model regresi. Berdasarkan hasil kajian, beberapa model regresi telah dibina menggunakan analisa variasi dan model regrasi. Ujian pengesahan turut dijalankan terhadap beberapa model regresi terpilih. Keputusan ujian pengesahan mempamerkan kualiti prestasi yang baik dengan model regresi yang dicadangkan. Kesimpulannya, maklumat data berkaitan rawatan alkali pada keadaan optimum yang disampaikan melalui disertasi ini dijangka mampu meningkatkan pemahaman dan memberi pengetahuan berkaitan parameter penting yang terlibat dalam mengoptimumkan proses rawatan alkali yang digunakan secara meluas untuk rawatan permukaan gentian asli.

CONTENTS

CHAPTER 2 LITERATURE REVIEW

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

$\widehat{y_1}$	-	Predicted or estimates response
y	-	Measured responses variable
b_1, b_2, b_3	-	Regression coefficients
b_o	-	Intercept
ε	-	Experimental error
α	-	Alpha or Significance level of the test
ANOVA	-	Analysis of variance
ASTM	-	American Society for Testing and Materials
CCD	-	Central Composite Design
D	-	Desirability functions
d	-	Depth of specimen (mm)
d	-	Impactor diameter
DF	-	Degrees of freedom
DIN	-	German Institute for Standardisation
DMA	-	Dynamic Mechanical Analysis
DOE	-	Design of experiments
E_{max}	-	Impact energy (J)
EP	-	Epoxy
FCCCD	-	Face Centered Center Composite Design
GRP	-	Glass reinforced polymer
H_a	-	Alternate or experimental hypothesis
H_o	-	Null hypothesis

IFSS	-	Interfacial shear strength
ISO	-	International Organization for Standardization
KMnO4	-	Potassium Permanganate
L	-	Support span length (mm)
L	-	length of fiber
$\boldsymbol{L_o}$	-	Length of elementary unit of the fiber
m	-	Number of responses
m	-	Weibull modulus
MAPP	-	Maleic Anhydride Polypropylene
MEKP	-	Methyl Ethyl Ketone Peroxide
MS	-	Mean squares
NaOH	-	Sodium hydroxide
NKTB	-	The National Kenaf and Tobacco Board
-OH	-	Hydroxyl groups
OVAT	-	One variable at a time
p	-	maximum probability
PE	-	Polyethylene
P_f	-	Probability index or estimators
$\boldsymbol{P_f(\sigma)}$	-	Probability of failure
PLA	-	Poly- Lactic Acid
PP	-	Polypropylene
PP	-	Polypropylene
PS	-	Polystyrene
PUR	-	Polyurethanes
PVC	-	Polyvinyl chloride
R	-	Rate of crosshead motion (mm/min)
R^2	-	Coefficient of determination
RSM	-	Response surface methodology
RT	-	Room temperature
S	-	Standard error of a regression

SEM	-	Scanning electron microscope
SS	-	Sum of squares
σ	-	Stress
σ_o	-	Characteristic strength
σ_{υ}	-	Lowest value of strength
σ_{impact}	-	Impact strength (kJ/m^2)
TAPPI	-	Technical Association of Pulp and Paper Industry
TGA	-	Thermo gravimetric analysis
UP	-	Unsaturated polyesters
UTS	-	Ultimate tensile stress
$\boldsymbol{v}$	-	Volume fraction
$\boldsymbol{V}$	-	Ratio of volume
$\boldsymbol{V_f}$	-	Volume fraction
$\boldsymbol{V_c}$	-	Composite volume
$\boldsymbol{w}$	-	Weight fraction
$\boldsymbol{W}$	-	Ratio of weight
$\boldsymbol{W_f}$	-	Weight fraction
$\boldsymbol{x_1}$	-	Alkali concentration (w/v%)
$\boldsymbol{x_1 x_2}$	-	Interaction
$\boldsymbol{x_2}$	-	Immersion time (min)
$\boldsymbol{x_3}$	-	Immersion temperature (^{o}C)
Z	-	Rate of staining of the outer fiber (mm/mm/min)

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

"We do not *inherit* the earth from our ancestors, we borrow it from our children" is an ancient Indian proverb that could be a suitable phrase to emphasize the global challenges on environmental issues and energy crisis nowadays. As the world population increase rapidly, intense pressures are placed on earth resources to provide an adequate supply of food and other compulsory needs to support this incredible pace of change. According to the Concise Report on the World Population Situation in 2014, the world population was over 7 billion in late 2011 and expected to reach 9 billion people by 2050. In conjunction with increasing number of world population growth, it gives a significant impact on environmental and energy issues. The global crisis like climate change, oil peak, water resources, sanitary landfill, deforestation and many others challenge closely affected with the human activities either from its needs or from its wastes. The work presented in this thesis is not an attempt to solve the world problems but this is a small effort in contributing to the environmental sustainability aspiration. For that reason, this chapter discussed the overview of the study begins with research background section and followed by problem statement section. Research objectives, research contributions, research scopes, research methodology and research significance are presented in following section. Thesis organization was written at the end of this chapter.

REFERENCES

1. UN.(2014). *Unitied Nations : Prototype Global Sustainable Development Report*. Retrieved on August, 2014, Available from http://sustainabledevelopment.un.org/globalsdreport/
2. Vilaplana, Francisco, Stromberg Emma and Karlsson Sigbritt. Environmental and resource aspects of sustainable biocomposites. *Polymer Degradation and Stability*. 2010. 95 (11): 2147-2161.
3. Kaebernick, H., Kara S. and Sun M. Sustainable product development and manufacturing by considering environmental requirements. *Robotics and Computer-Integrated Manufacturing*. 2003. 19 (6): 461-468.
4. Olson, Eric G. Business as environmental steward : The growth of greening. *Journal of Business Strategy*. 2009. 30 (5): 4-13.
5. Jayal, A. D., Badurdeen F., et al. Sustainable manufacturing: Modeling and optimization challenges at the product, process and system levels. *CIRP Journal of Manufacturing Science and Technology*. 2010. 2 (3): 144-152.
6. Bledzki, A. K. and Gassan J. Composites reinforced with cellulose based fibres. *Progress in Polymer Science*. 1999. 24 (2): 221-274.
7. Mohanty, A. K., Misra M. and Hinrichsen G. Biofibres, biodegradable polymers and biocomposites: An overview. *Macromolecular Materials and Engineering*. 2000. 276-277 (1): 1-24.
8. Wambua, Paul, Ivens Jan and Verpoest Ignaas. Natural fibres: can they replace glass in fibre reinforced plastics? *Composites Science and Technology*. 2003. 63 (9): 1259-1264.
9. Satyanarayana, Kestur G., Arizaga Gregorio G. C. and Wypych Fernando. Biodegradable composites based on lignocellulosic fibers--An overview. *Progress in Polymer Science*. 2009. 34 (9): 982-1021.
10. Joshi, SV, Drzal LT, et al. Are natural fiber composites environmentally superior to glass fiber reinforced composites? *Composites Part A: Applied Science and Manufacturing*. 2004. 35 (3): 371-376.
11. La Mantia, F. P. and Morreale M. Green composites: A brief review. *Composites Part A: Applied Science and Manufacturing*. 2011. 42 (6): 579-588.
12. Rodríguez, N. J., Yáñez-Limón M., et al. Assessment of coconut fibre insulation characteristics and its use to modulate temperatures in concrete slabs with the aid of a finite element methodology. *Energy and Buildings*. 2011. 43 (6): 1264-1272.
13. Koronis, Georgios, Silva Arlindo and Fontul Mihail. Green composites: A review of adequate materials for automotive applications. *Composites Part B: Engineering*. 2013. 44 (1): 120-127.

14. Medina, Luisa, Schledjewski Ralf and Schlarb Alois K. Process related mechanical properties of press molded natural fiber reinforced polymers. *Composites Science and Technology*. 2009. 69 (9): 1404-1411.
15. Shalwan, A. and Yousif B. F. In state of art: Mechanical and tribological behaviour of polymeric composites based on natural fibres. *Materials and Design*. 2013. 48 14-24.
16. Hughes, Mark. Defects in natural fibres: their origin, characteristics and implications for natural fibre-reinforced composites. *Journal of Materials Science*. 2011. 1-11.
17. Shinji, Ochi. Mechanical properties of kenaf fibers and kenaf/PLA composites. *Mechanics of Materials*. 2008. 40 (4-5): 446-452.
18. Du, Y. *An applied investigation of kenaf-based fiber/polymer composites as potential lightweight materials for automotive components*. PHD Thesis. Mississippi State University; 2010
19. Virk, Amandeep Singh, Hall Wayne and Summerscales John. Failure strain as the key design criterion for fracture of natural fibre composites. *Composites Science and Technology*. 2010. 70 (6): 995-999.
20. Dittenber, David B. and GangaRao Hota V. S. Critical review of recent publications on use of natural composites in infrastructure. *Composites Part A: Applied Science and Manufacturing*. 2012. 43 (8): 1419-1429.
21. Hu, Rui-Hua, Sun Min-young and Lim Jae-Kyoo. Moisture absorption, tensile strength and microstructure evolution of short jute fiber/polylactide composite in hygrothermal environment. *Materials & Design*. 2010. 31 (7): 3167-3173.
22. De Rosa, Igor Maria, Santulli Carlo and Sarasini Fabrizio. Mechanical and thermal characterization of epoxy composites reinforced with random and quasi-unidirectional untreated Phormium tenax leaf fibers. *Materials & Design*. 2010. 31 (5): 2397-2405.
23. Kalia, Susheel, Dufresne Alain, et al. Cellulose-Based Bio- and Nanocomposites: A Review. *International Journal of Polymer Science*. 2011. 2011
24. De Rosa, Igor Maria, Kenny Josè Maria, et al. Morphological, thermal and mechanical characterization of okra (Abelmoschus esculentus) fibres as potential reinforcement in polymer composites. *Composites Science and Technology*. 2010. 70 (1): 116-122.
25. Anuar, H. and Zuraida A. Improvement in mechanical properties of reinforced thermoplastic elastomer composite with kenaf bast fibre. *Composites Part B: Engineering*. 2011. 42 (3): 462-465.
26. Ministry of Plantation Industries and Commodities Malaysia, MPIC.(2014). *Kenaf sales to reach RM 80 million in 2020*. Retrieved on November 2014, Available from http://www.kppk.gov.my/index.php/news-cutting/3471-kenaf-kenaf-sales-to-reach-rm80-million-in-2020.html
27. Hashim, M.Y., Roslan M.N., et al. Mercerization Treatment Parameter Effect on Natural Fiber Reinforced Polymer Matrix Composite: A Brief Review. *World Academy of Science, Engineering and Technology*. 2012. 68 1638-1644.
28. Rekab, Kamel Rekab and Shaikh Muzaffar. Statistical design of experiments with engineering applications. CRC PressI Llc. 2005.

29. ScienceDirect.(2014). *Number of article regarding natural fiber and synthetic fiber published from 2005 to 2015*. Retrieved on 21 December, 2014, Available from http://www.sciencedirect.com
30. Li, Xue, Tabil Lope and Panigrahi Satyanarayan. Chemical Treatments of Natural Fiber for Use in Natural Fiber-Reinforced Composites: A Review. *Journal of Polymers and the Environment*. 2007. 15 (1): 25-33.
31. Briassoulis, Demetres and Dejean Cyril. Critical Review of Norms and Standards for Biodegradable Agricultural Plastics Part I. Biodegradation in Soil. *Journal of Polymers and the Environment*. 2010. 18 (3): 384-400.
32. Faruk, Omar, Bledzki Andrzej K., et al. Biocomposites reinforced with natural fibers: 2000–2010. *Progress in Polymer Science*. 2012. 37 (11): 1552-1596.
33. Eichhorn, S. J., Baillie C. A., et al. Review: Current international research into cellulosic fibres and composites. *Journal of Materials Science*. 2001. 36 (9): 2107-2131.
34. Akil, H. M., Omar M. F., et al. Kenaf Fiber Reinforced Composites: A Review. *Materials & Design*. 2011. Volume 32, September 2011 (Issues 8-9): Pages 4107-4121
35. Azwa, Z. N., Yousif B. F., et al. A review on the degradability of polymeric composites based on natural fibres. *Materials & Design*. 2013. 47 (0): 424-442.
36. Rowell, R.M. Agro-fibre based composites: Exploring the limits. *Proceeding of the 18th Riso International Symposium on Material Science : Polymeric Composites - Expanding the Limits*. 1997. 127-133
37. Abdel-Halim, E. S., El-Rafie M. H. and Kohler R. Surface Characterization of Differently Pretreated Flax Fibers and Their Application in Fiber-Reinforced Composites. *Polymer-Plastics Technology and Engineering*. 2008. 47 (1): 58 - 65.
38. Eichhorn, S., Dufresne A., et al. Review: current international research into cellulose nanofibres and nanocomposites. *Journal of Materials Science*. 2010. 45 (1): 1-33.
39. Summerscales, John, Dissanayake Nilmini P. J., et al. A review of bast fibres and their composites. Part 1 - Fibres as reinforcements. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (10): 1329-1335.
40. Jawaid, MHPS and Abdul Khalil HPS. Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review. *Carbohydrate Polymers*. 2011. 86 (1): 1-18.
41. Kalia, Susheel, Kaith B. S. and Kaur Inderjeet. Pretreatments of natural fibers and their application as reinforcing material in polymer composites—A review. *Polymer Engineering & Science*. 2009. 49 (7): 1253-1272.
42. Asasutjarit, Chanakan, Charoenvai Sarocha, et al. Materials and mechanical properties of pretreated coir-based green composites. *Composites Part B: Engineering*. 2009. 40 (7): 633-637.
43. Murali Mohan Rao, K., Mohana Rao K. and Ratna Prasad A. V. Fabrication and testing of natural fibre composites: Vakka, sisal, bamboo and banana. *Materials & Design*. 2010. 31 (1): 508-513.
44. Sapuan, S. M., Leenie A., et al. Mechanical properties of woven banana fibre reinforced epoxy composites. *Materials & Design*. 2006. 27 (8): 689-693.

45. Borsellino, C. and Bella G. Di. Paper-reinforced biomimetic cellular structures for automotive applications. *Materials & Design*. 2009. 30 (10): 4054-4059.
46. Davis, G. and Song J. H. Biodegradable packaging based on raw materials from crops and their impact on waste management. *Industrial Crops and Products*. 2006. 23 (2): 147-161.
47. Kymäläinen, Hanna-Riitta and Sjöberg Anna-Maija. Flax and hemp fibres as raw materials for thermal insulations. *Building and Environment*. 2008. 43 (7): 1261-1269.
48. Elsaid, A., Dawood M., et al. Mechanical properties of kenaf fiber reinforced concrete. *Construction and Building Materials*. 2011. 25 (4): 1991-2001.
49. Sgriccia, Nikki and Hawley M. C. Thermal, morphological, and electrical characterization of microwave processed natural fiber composites. *Composites Science and Technology*. 2007. 67 (9): 1986-1991.
50. Jawaid, M., Abdul Khalil H., et al. Hybrid Composites Made from Oil Palm Empty Fruit Bunches/Jute Fibres: Water Absorption, Thickness Swelling and Density Behaviours. *Journal of Polymers and the Environment*. 2010. 1-4.
51. John, MJ and Anandjiwala RD. Recent developments in chemical modification and characterization of natural fiber reinforced composites. *Polymer composites*. 2008. 29 (2): 187-207.
52. Summerscales, John, Dissanayake Nilmini P. J., et al. A review of bast fibres and their composites. Part 1 – Fibres as reinforcements. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (10): 1329-1335.
53. Taj, S, Munawar M.A. and Khan S. Natural fiber-reinforced polymer composites. *Proceeding Pakistan Academy of Sciences*. 2007. 44 (2): 129.
54. Sgriccia, N., Hawley M. C. and Misra M. Characterization of natural fiber surfaces and natural fiber composites. *Composites Part A: Applied Science and Manufacturing*. 2008. 39 (10): 1632-1637.
55. Gassan, Jochen. A study of fibre and interface parameters affecting the fatigue behaviour of natural fibre composites. *Composites Part A: Applied Science and Manufacturing*. 2002. 33 (3): 369-374.
56. Valadez-Gonzalez, A., Cervantes-Uc J. M., et al. Effect of fiber surface treatment on the fiber-matrix bond strength of natural fiber reinforced composites. *Composites Part B: Engineering*. 1999. 30 (3): 309-320.
57. Goda, Koichi, Sreekala M. S., et al. Improvement of plant based natural fibers for toughening green composites--Effect of load application during mercerization of ramie fibers. *Composites Part A: Applied Science and Manufacturing*. 2006. 37 (12): 2213-2220.
58. George, Jayamol, Sreekala M. S. and Thomas Sabu. A review on interface modification and characterization of natural fiber reinforced plastic composites. *Polymer Engineering & Science*. 2001. 41 (9): 1471-1485.
59. Sinha, E., Rout S. K. and Barhai P. K. Study of the structural and thermal properties of plasma treated jute fibre. *Applied Physics A: Materials Science & Processing*. 2008. 92 (2): 283-290.
60. Bogoeva-Gaceva, G, Avella Maurizio, et al. Natural fiber eco-composites. *Polymer composites*. 2007. 28 (1): 98-107.
61. Xie, Yanjun, Hill Callum A. S., et al. Silane coupling agents used for natural fiber/polymer composites: A review. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (7): 806-819.

62. Aziz, Sharifah H. and Ansell Martin P. The effect of alkalization and fibre alignment on the mechanical and thermal properties of kenaf and hemp bast fibre composites: Part 1 - polyester resin matrix. *Composites Science and Technology*. 2004. 64 (9): 1219-1230.
63. Mohan, T. P. and Kanny K. Chemical treatment of sisal fiber using alkali and clay method. *Composites Part A: Applied Science and Manufacturing*. 2012. 43 (11): 1989-1998.
64. Islam, M. S., Pickering K. L. and Foreman N. J. Influence of alkali treatment on the interfacial and physico-mechanical properties of industrial hemp fibre reinforced polylactic acid composites. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (5): 596-603.
65. Sanadi, AR, Caulfield DF, et al. Renewable agricultural fibers as reinforcing fillers in plastics: Mechanical properties of kenaf fiber-polypropylene composites. *Industrial & Engineering Chemistry Research*. 1995. 34 (5): 1889-1896.
66. Abdul Khalil, H. P. S., Yusra A. F. Ireana, et al. Cell wall ultrastructure, anatomy, lignin distribution, and chemical composition of Malaysian cultivated kenaf fiber. *Industrial Crops and Products*. 2010. 31 (1): 113-121.
67. Aji, IS, Sapuan SM, et al. Kenaf fibres as reinforcement for polymeric composites : A review. *International Journal of Mechanical and Materials Engineering*. 2009. 4 (3): 239-248.
68. Ogbomo, S.M., Chapman K., et al. Benefits of low kenaf loading in biobased composites of poly (L-lactide) and kenaf fiber. *Journal of Applied Polymer Science*. 2009. 112 (3): 1294-1301.
69. Saba, N., Paridah M. T. and Jawaid M. Mechanical properties of kenaf fibre reinforced polymer composite: A review. *Construction and Building Materials*. 2015. 76 (0): 87-96.
70. Bismarck, A., Mishra S. and Lampke T. Plant fibers as reinforcement for green composites. In: A.K. Mohanty, M. Misra, and L.T. Drzal. *Natural fibers, Biopolymers and Biocomposites*. Boca Raton: Taylor & Francis. 45-50: 2005
71. Rowell, RM, Sanadi AR, et al. Utilization of natural fibers in plastic composites: Problems and opportunities. *Lignocellulosic-Plastic Composites, São Paulo, USP & UNESP*. 1997. 23-51.
72. Mohanty, A.K, Misra, M, Drzal, L.T. Surface modifications of natural fibers and performance of the resulting biocomposites: An overview *Composite Interfaces*. 2001. 8 (5): 313-343.
73. Lai, W. L., Mariatti M. and Jani S. Mohamad. The Properties of Woven Kenaf and Betel Palm Reinforced Unsaturated Polyester Composites. *Polymer-Plastics Technology and Engineering*. 2008. 47 (12): 1193 - 1199.
74. Fiore, V, Di Bella G and Valenza A. The effect of alkaline treatment on mechanical properties of kenaf fibers and their epoxy composites. *Composites Part B: Engineering*. 2015. 68 14-21.
75. Mwaikambo, L. Y. and Ansell M. P. The determination of porosity and cellulose content of plant fibers by density methods. *Journal of Materials Science Letters*. 2001. 20 (23): 2095-2096.
76. Symington, Mark C., Banks W.M., et al. Tensile Testing of Cellulose Based Natural Fibers for Structural Composite Applications. *Journal of Composite Materials*. 2009. 43 (9): 1083-1108.

77. Naturali, K.E.F.I Fibre. *Technical information : Properties of principal fibers*. 2014 [cited 2014 20 December]; Available from: http://www.kenaf-fiber.com/en/infotec-tabella10.asp.
78. Suzuki, Kohji, Kimpara Isao, et al. Cross-sectional area measurement and monofilament strength test of kenaf bast fibers. *Journal Society of Materials Science Japan*. 2005. 54 (8): 887.
79. Shibata, Shinichi, Cao Yong and Fukumoto Isao. Press forming of short natural fiber-reinforced biodegradable resin: Effects of fiber volume and length on flexural properties. *Polymer Testing*. 2005. 24 (8): 1005-1011.
80. Shibata, Shinichi, Cao Yong and Fukumoto Isao. Flexural modulus of the unidirectional and random composites made from biodegradable resin and bamboo and kenaf fibres. *Composites Part A: Applied Science and Manufacturing*. 2008. 39 (4): 640-646.
81. Modibbo, UU, Aliyu BA and Nkafamiya II. The effect of mercerization media on the physical properties of local plant bast fibres. *International Journal of Physical Sciences*. 2009. 4 (11): 698-704.
82. Lee, S., Shi S.Q., et al. Properties of unidirectional kenaf fiber–polyolefin laminates. *Polymer composites*. 2010. 31 (6): 1067-1074.
83. Ishak, M R, Leman Z, et al. Mechanical properties of kenaf bast and core fibre reinforced unsaturated polyester composites. *IOP Conference Series: Materials Science and Engineering*. 2010. 11 (1): 012006.
84. Nitta, Y., Goda K., et al. Cross-sectional area evaluation and tensile properties of alkali-treated kenaf fibres. *Composites Part A: Applied Science and Manufacturing*. 2013. 49 (0): 132-138.
85. Mahjoub, Reza, Yatim Jamaludin Mohamad, et al. Tensile properties of kenaf fiber due to various conditions of chemical fiber surface modifications. *Construction and Building Materials*. 2014. 55 (0): 103-113.
86. Xue, Yibin, Du Yicheng, et al. Temperature and loading rate effects on tensile properties of kenaf bast fiber bundles and composites. *Composites Part B: Engineering*. 2009. 40 (3): 189-196.
87. Edeerozey, A. M. Mohd, Akil Hazizan Md, et al. Chemical modification of kenaf fibers. *Materials Letters*. 2007. 61 (10): 2023-2025.
88. Graupner, Nina, Herrmann Axel S. and Müssig Jörg. Natural and man-made cellulose fibre-reinforced poly(lactic acid) (PLA) composites: An overview about mechanical characteristics and application areas. *Composites Part A: Applied Science and Manufacturing*. 2009. 40 (6-7): 810-821.
89. Özturk, Sultan. Effect of Fiber Loading on the Mechanical Properties of Kenaf and Fiberfrax Fiber-reinforced Phenol-Formaldehyde Composites. *Journal of Composite Materials*. 2010. 44 (19): 2265-2288.
90. Mazuki, Adlan Akram Mohamad, Akil Hazizan Md, et al. Degradation of dynamic mechanical properties of pultruded kenaf fiber reinforced composites after immersion in various solutions. *Composites Part B: Engineering*. 2011. 42 (1): 71-76.
91. Akil, H., Zamri M. H. and Osman M. R. 5 - The use of kenaf fibers as reinforcements in composites. In: O. Faruk and M. Sain. *Biofiber Reinforcements in Composite Materials*. Woodhead Publishing. 138-161: 2015
92. Abdul Khalil, H. A. S., Suraya N. L., et al. Mechanical and thermal properties of chemical treated kenaf fibres reinforced polyester composites. *Journal of Composite Materials*. 2013. 47 (26): 3343-3350.

93. Nishino, Takashi, Hirao Koichi, et al. Kenaf reinforced biodegradable composite. *Composites Science and Technology*. 2003. 63 (9): 1281-1286.
94. Saiman, Mohd Pahmi. *2 Dimension woven kenaf reinforced unsaturated polyester composite*. Phd. Universiti Tun Hussein Onn Malaysia; 2014
95. John, Maya Jacob, Francis Bejoy, et al. Effect of chemical modification on properties of hybrid fiber biocomposites. *Composites Part A: Applied Science and Manufacturing*. 2008. 39 (2): 352-363.
96. Sreekumar, P. A., Thomas Selvin P., et al. Effect of fiber surface modification on the mechanical and water absorption characteristics of sisal/polyester composites fabricated by resin transfer molding. *Composites Part A: Applied Science and Manufacturing*. 2009. 40 (11): 1777-1784.
97. Vilay, V., Mariatti M., et al. Effect of fiber surface treatment and fiber loading on the properties of bagasse fiber-reinforced unsaturated polyester composites. *Composites Science and Technology*. 2008. 68 (3-4): 631-638.
98. De Rosa, Igor Maria, Kenny José M., et al. Effect of chemical treatments on the mechanical and thermal behaviour of okra (Abelmoschus esculentus) fibres. *Composites Science and Technology*. 2011. 71 (2): 246-254.
99. Bachtiar, D., Sapuan S. M. and Hamdan M. M. The effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites. *Materials & Design*. 2008. 29 (7): 1285-1290.
100. Cho, Donghwan, Kim Jin Myung, et al. Effect of alkali pre-treatment of jute on the formation of jute-based carbon fibers. *Materials Letters*. 2011. 65 (10): 1492-1494.
101. Ku, H., Wang H., et al. A review on the tensile properties of natural fiber reinforced polymer composites. *Composites Part B: Engineering*. 2011. 42 (4): 856-873.
102. Prasad, S. V. , Pavithran C. and Rohatgi P. K. Alkali treatment of coir fibres for coir-polyester composites. *Journal of Materials Science*. 1983. 18 (5): 1443-1454.
103. Mwaikambo, LY and Ansell MP. The effect of chemical treatment on the properties of hemp, sisal, jute and kapok fibres for composite reinforcement. *Die angewandte makromolekulare Chemie*. 1999. 272 (1): 108-116.
104. Cao, Y., Shibata S. and Fukumoto I. Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatments. *Composites Part A: Applied Science and Manufacturing*. 2006. 37 (3): 423-429.
105. Rokbi, Mansour, Osmani Hocine, et al. Effect of chemical treatment on flexure properties of natural fiber-reinforced polyester composite. *Procedia Engineering*. 2011. 10 2092-2097.
106. Mwaikambo, Leonard Y. and Ansell Martin P. Chemical modification of hemp, sisal, jute, and kapok fibers by alkalization. *Journal of Applied Polymer Science*. 2002. 84 (12): 2222-2234.
107. Sreenivasan, S., Iyer P. Bhama and Iyer K. R. Krishna. Influence of delignification and alkali treatment on the fine structure of coir fibres. *Journal of Materials Science*. 1996. 31 (3): 721-726.
108. Kabir, M. M., Wang H., et al. Tensile properties of chemically treated hemp fibres as reinforcement for composites. *Composites Part B: Engineering*. 2013. 53 (0): 362-368.

109. Mwaikambo, L.Y and Ansell M. Mechanical properties of alkali treated plant fibres and their potential as reinforcement materials. I. hemp fibres. *Journal of Materials Science*. 2006. 41 (8): 2483-2496.
110. Obi Reddy, K., Uma Maheswari C., et al. Tensile and structural characterization of alkali treated Borassus fruit fine fibers. *Composites Part B: Engineering*. 2013. 44 (1): 433-438.
111. Mwaikambo, L.Y. Tensile properties of alkalised jute fibres. *Bioresources*. 2009. 4 (2): 566-588.
112. Boopathi, L., Sampath P. S. and Mylsamy K. Investigation of physical, chemical and mechanical properties of raw and alkali treated Borassus fruit fiber. *Composites Part B: Engineering*. 2012. 43 (8): 3044-3052.
113. Nor Azowa Ibrahim, Kamarul Arifin Hadithon and Abdan Khalina. Effect of Fiber Treatment on Mechanical Properties of Kenaf Fiber-Ecoflex Composites. *Journal of Reinforced Plastics and Composites*. 2010. 29 (14): 2192-2198.
114. Wang, Wei-ming, Cai Zai-sheng and Yu Jian-yong. Study on the chemical modification process of jute fiber. *Journal of Engineered Fibers and Fabrics*. 2008. 3 (2): 1-11.
115. Saha, Prosenjit, Manna Suvendu, et al. Enhancement of tensile strength of lignocellulosic jute fibers by alkali-steam treatment. *Bioresource Technology*. 2010. 101 (9): 3182-3187.
116. Munawar, Sasa, Umemura Kenji, et al. Effects of alkali, mild steam, and chitosan treatments on the properties of pineapple, ramie, and sansevieria fiber bundles. *Journal of Wood Science*. 2008. 54 (1): 28-35.
117. Kim, Jun Tae and Netravali Anil N. Mercerization of sisal fibers: Effect of tension on mechanical properties of sisal fiber and fiber-reinforced composites. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (9): 1245-1252.
118. Roy, Aparna, Chakraborty Sumit, et al. Improvement in mechanical properties of jute fibres through mild alkali treatment as demonstrated by utilisation of the Weibull distribution model. *Bioresource Technology*. 2012. 107 (0): 222-228.
119. Rodriguez, E.S and Vazquez A. Alkali treatment of Jute fabrics : Influence on the processing conditions and the mechanical properties of their composites. *International Conference on Flow Processes in Composite Materials.* 11-13 July. 2006.
120. Mylsamy, K. and Rajendran I. Influence of alkali treatment and fibre length on mechanical properties of short Agave fibre reinforced epoxy composites. *Materials & Design*. 2011. 32 (8–9): 4629-4640.
121. Gomes, A, Goda K and Ohgi J. Effects of alkali treatment to reinforcement on tensile properties of curaua fiber green composites. *JSME International Journal Series A*. 2004. 47 (4): 541-546.
122. Kabir, M. M., Wang H., et al. Effects of chemical treatments on hemp fibre structure. *Applied Surface Science*. 2013. 276 (0): 13-23.
123. Gu, Huang. Tensile behaviours of the coir fibre and related composites after NaOH treatment. *Materials & Design*. 2009. 30 (9): 3931-3934.
124. Park, Joung-Man, Quang Son Tran, et al. Interfacial evaluation of modified Jute and Hemp fibers/polypropylene (PP)-maleic anhydride polypropylene copolymers (PP-MAPP) composites using micromechanical technique and

nondestructive acoustic emission. *Composites Science and Technology*. 2006. 66 (15): 2686-2699.
125. Rahman Khan, Md Majibur, Chen Ying, et al. Fineness and tensile properties of hemp (Cannabis sativa L.) fibres. *Biosystems Engineering*. 2011. 108 (1): 9-17.
126. Andersons, J., Poriķe E. and Spārniņš E. Modeling strength scatter of elementary flax fibers: The effect of mechanical damage and geometrical characteristics. *Composites Part A: Applied Science and Manufacturing*. 2011. 42 (5): 543-549.
127. Aslan, Mustafa, Chinga-Carrasco Gary, et al. Strength variability of single flax fibres. *Journal of Materials Science*. 2011. 46 (19): 6344-6354.
128. Alves Fidelis, Maria Ernestina, Pereira Thatiana Vitorino Castro, et al. The effect of fiber morphology on the tensile strength of natural fibers. *Journal of Materials Research and Technology*. 2013. 2 (2): 149-157.
129. Wirawan, Riza, Sapuan S.M., et al. Properties of sugarcane bagasse/ poly(vinyl chloride) composites after various treatments. *Journal of Composite Materials*. 2011. 45 (16): 1667-1674.
130. Ishak, M., Sapuan S., et al. Characterization of sugar palm (Arenga Pinnata) fibres. *Journal of Thermal Analysis and Calorimetry*. 2012. 109 (2): 981-989.
131. Doan, Thi-Thu-Loan, Gao Shang-Lin and Mäder Edith. Jute/polypropylene composites I. Effect of matrix modification. *Composites Science and Technology*. 2006. 66 (7-8): 952-963.
132. Nirmal, Umar, Yousif B. F., et al. Effect of betelnut fibres treatment and contact conditions on adhesive wear and frictional performance of polyester composites. *Wear*. 2010. 268 (11-12): 1354-1370.
133. Nirmal, U., Singh N., et al. On the effect of different polymer matrix and fibre treatment on single fibre pullout test using betelnut fibres. *Materials & Design*. 2011. 32 (5): 2717-2726.
134. Awal, A., Cescutti G., et al. Interfacial studies of natural fibre/polypropylene composites using single fibre fragmentation test (SFFT). *Composites Part A: Applied Science and Manufacturing*. 2011. 42 (1): 50-56.
135. Zafeiropoulos, N. E. and Baillie C. A. A study of the effect of surface treatments on the tensile strength of flax fibres: Part II. Application of Weibull statistics. *Composites Part A: Applied Science and Manufacturing*. 2007. 38 (2): 629-638.
136. Defoirdt, Nele, Biswas Subhankar, et al. Assessment of the tensile properties of coir, bamboo and jute fibre. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (5): 588-595.
137. Guo, M., Zhang T. H., et al. Tensile strength analysis of palm leaf sheath fiber with Weibull distribution. *Composites Part A: Applied Science and Manufacturing*. 2014. 62 (0): 45-51.
138. Mohanty, A. K., Misra M. and Drzal L. T. Sustainable Bio-Composites from Renewable Resources: Opportunities and Challenges in the Green Materials World. *Journal of Polymers and the Environment*. 2002. 10 (1): 19-26.
139. Gibson, Ronald F. Principles of Composite Material Mechanics. 2nd Edition. *Boca Raton*. Taylor & Francis Group and CRC Press. 2007.
140. Black, J.T. and Kohser Ronald A. DeGarmo's Materials and Processes in Manufacturing. Tenth Edition. John Wiley & Sons, Inc. 2008.

141. Mallick, P.K. Fiber Reinforced Composite - Materials, Manufacturing and Design. Third Edition. *Boca Raton*. CRC Press and Taylor & Francis Group. 2008.
142. Aziz, Sharifah H., Ansell Martin P., et al. Modified polyester resins for natural fibre composites. *Composites Science and Technology*. 2005. 65 (3-4): 525-535.
143. Jayabal, S. and Natarajan U. Influence of fiber parameters on tensile, flexural, and impact properties of nonwoven coir–polyester composites. *The International Journal of Advanced Manufacturing Technology*. 2010. 1-10.
144. Sastra, H. Y., Siregar J. P., et al. Tensile Properties of Arenga pinnata Fiber-Reinforced Epoxy Composites. *Polymer-Plastics Technology and Engineering*. 2006. 45 (1): 149-155.
145. Ismail, H., Hamid Abdullah A. and Abu Bakar A. Kenaf Core Reinforced High-density Polyethylene/Soya Powder Composites: The Effects of Filler Loading and Compatibilizer. *Journal of Reinforced Plastics and Composites*. 2010. 29 (16): 2489-2497.
146. Rassmann, S., Paskaramoorthy R. and Reid R. G. Effect of resin system on the mechanical properties and water absorption of kenaf fibre reinforced laminates. *Materials & Design*. 2011. 32 (3): 1399-1406.
147. Rassmann, S., Reid R. G. and Paskaramoorthy R. Effects of processing conditions on the mechanical and water absorption properties of resin transfer moulded kenaf fibre reinforced polyester composite laminates. *Composites Part A: Applied Science and Manufacturing*. 2010. 41 (11): 1612-1619.
148. Mohanty, A. K., Wibowo A., et al. Effect of process engineering on the performance of natural fiber reinforced cellulose acetate biocomposites. *Composites Part A: Applied Science and Manufacturing*. 2004. 35 (3): 363-370.
149. Bettini, S. H. P., Bicudo A. B. L. C., et al. Investigation on the use of coir fiber as alternative reinforcement in polypropylene. *Journal of Applied Polymer Science*. 2010. 118 (5): 2841-2848.
150. Azwa, Z. N. and Yousif B. F. Characteristics of kenaf fibre/epoxy composites subjected to thermal degradation. *Polymer Degradation and Stability*. 2013. 98 (12): 2752-2759.
151. Dai, D. and Fan M. 1 - Wood fibres as reinforcements in natural fibre composites: structure, properties, processing and applications. In: A. Hodzic and R. Shanks. *Natural Fibre Composites*. Woodhead Publishing. 3-65: 2014
152. Leman, Z., Sapuan S. M., et al. The Effect of Environmental Treatments on Fiber Surface Properties and Tensile Strength of Sugar Palm Fiber-Reinforced Epoxy Composites. *Polymer-Plastics Technology and Engineering*. 2008. 47 (6): 606 - 612.
153. Balakrishna, Adavi, Rao Damera Nageswara and Rakesh Adapa Swamy. Characterization and modeling of process parameters on tensile strength of short and randomly oriented Borassus Flabellifer (Asian Palmyra) fiber reinforced composite. *Composites Part B: Engineering*. 2013. 55 (0): 479-485.
154. Ahmad, S. H., Rasid R., et al. Polyester-Kenaf composites: Effects of alkali fiber treatment and toughening of matrix using liquid natural rubber. *Journal of Composite Materials*. 2011. 45 (2): 203-217.
155. Yousif, B. F., Shalwan A., et al. Flexural properties of treated and untreated kenaf/epoxy composites. *Materials & Design*. 2012. 40 (0): 378-385.

156. Bartus, S. D. and Vaidya U. K. Performance of long fiber reinforced thermoplastics subjected to transverse intermediate velocity blunt object impact. *Composite Structures*. 2005. 67 (3): 263-277.
157. Dhakal, H. N., Zhang Z. Y., et al. The low velocity impact response of non-woven hemp fibre reinforced unsaturated polyester composites. *Composite Structures*. 2007. 81 (4): 559-567.
158. Roslan, M. N., Ismail A. E., et al. Modelling Analysis on Mechanical Damage of Kenaf Reinforced Composite Plates under Oblique Impact Loadings. *Applied Mechanics and Materials*. 2014. 465 1324-1328.
159. Dhakal, H. N., Arumugam V., et al. Influence of temperature and impact velocity on the impact response of jute/UP composites. *Polymer Testing*. 2014. 35 (0): 10-19.
160. Mathews, P. G. Design of Experiments with MINITAB. ASQ Quality Press. 2005.
161. Indrajit, M and Pradip, K. R. A review of optimization techniques in metal cutting processes. *Computers & Industrial Engineering*. 2006. (50): 15-34.
162. Kumar, Rahul, Kumar Kaushik and Bhowmik Sumit. Optimization of Mechanical Properties of Epoxy based Wood Dust Reinforced Green Composite Using Taguchi Method. *Procedia Materials Science*. 2014. 5 (0): 688-696.
163. Aimi, N. Nur, Anuar H., et al. Optimizing the parameters in durian skin fiber reinforced polypropylene composites by response surface methodology. *Industrial Crops and Products*. 2014. 54 (0): 291-295.
164. Sallih, Nabihah, Lescher Peter and Bhattacharyya Debes. Factorial study of material and process parameters on the mechanical properties of extruded kenaf fibre/polypropylene composite sheets. *Composites Part A: Applied Science and Manufacturing*. 2014. 61 (0): 91-107.
165. Shinoj, S., Visvanathan R. and Panigrahi S. Towards industrial utilization of oil palm fibre: Physical and dielectric characterization of linear low density polyethylene composites and comparison with other fibre sources. *Biosystems Engineering*. 2010. 106 (4): 378-388.
166. Sydenstricker, Thais H. D., Mochnaz Sandro and Amico Sandro C. Pull-out and other evaluations in sisal-reinforced polyester biocomposites. *Polymer Testing*. 2003. 22 (4): 375-380.
167. Montgomery, Douglas C. Design and analysis of experiments. 7th John Wiley & Sons. 2008.
168. Turner, J Rick. Introduction to Analysis of Variance: Design, Analyis & Interpretation. Sage. 2001.
169. Bizit, Systems. Minitab 16 Basic Module - Introduction to Minitab Basic Statistic. 2010. 177-179.
170. Bluman, Allan G. Elementary statistics: A step by step approach. McGraw-Hill. 2012.
171. Montgomery, Douglas C, Peck Elizabeth A and Vining G Geoffrey. Introduction to linear regression analysis. John Wiley & Sons. 2012.
172. Del Vecchio, RJ. Understanding design of experiments. Hanser Publishers. 1997.
173. Miles, Jeremy and Shevlin Mark. Applying regression and correlation: A guide for students and researchers. Sage. 2001.
174. Matthews, Frank L and Rawlings Rees D. Composite materials: engineering and science. Elsevier. 1999.

175. Zhang, Y., Wang X., et al. Weibull analysis of the tensile behavior of fibers with geometrical irregularities. *Journal of Materials Science*. 2002. 37 (7): 1401-1406.
176. Silva, Flavio de Andrade, Chawla Nikhilesh and Filho Romildo Dias de Toledo. Tensile behavior of high performance natural (sisal) fibers. *Composites Science and Technology*. 2008. 68 (15–16): 3438-3443.
177. Fothergill, JC. Estimating the cumulative probability of failure data points to be plotted on Weibull and other probability paper. *Electrical Insulation, IEEE Transactions on*. 1990. 25 (3): 489-492.
178. Athijayamani, A., Thiruchitrambalam M., et al. Mechanical properties of natural fibers reinforced polyester hybrid composite. *International Journal of Plastics Technology*. 2010. 1-13.
179. Mujumdar, Arun S. *Handbook of Industrial Drying*. 3rd Edition. *Andover*. CRC Press. 2007.
180. International, American Society for Testing and Materials (ASTM). *Standard Test Method for Density of High-Modulus Fibers.* Pennsylvania, D3800 – 99 (2010). D3800 – 99 (Reapproved 2010)
181. International, ASTM. *Standard Test Method for Tensile Strength and Young's Modulus of Fibers.* Pennsylvania, US, C1557-03 (Reapproved 2008). 2008
182. Pitkethly, M.J. The use of interfacial test methods in composite material development. In: C.J. Spragg and L.T. Drzal. *Fiber, Matrix and Interphase Properties*. West Conshohocken: ASTM STP. 34-46: 1996
183. Islam, M. S. *The influence of fiber processing and treatment on hemp fiber-epoxy and hemp fiber-PLA composites*. PHD Thesis. The University of Waikato; 2008
184. International, ASTM. *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.* Pennsylvania, US, D790-10. 2010
185. International, ASTM. *Standard Test Method for High Speed Puncture Properties of Plastics Using Load and Displacement Sensors.* West Conshohocken, D 3763 – 02. 2002
186. International, ASTM. *Standard Test Method for Tensile Properties of Plastics.* West Conshohocken, US, D638 – 10. 2010
187. Wan Azelee, Nur Izyan, Md Jahim Jamaliah, et al. Efficient removal of lignin with the maintenance of hemicellulose from kenaf by two-stage pretreatment process. *Carbohydrate Polymers*. 2014. 99 (0): 447-453.
188. Cao, Y, Sakamoto S and Goda K. Effects of heat and alkali treatments on mechanical properties of kenaf fibers. *Proceedings of 16th International Conference on Composite Materials, Kyoto Japan*. 2007. 1-4
189. Herrera-Franco, P. J. and Valadez-González A. A study of the mechanical properties of short natural-fiber reinforced composites. *Composites Part B: Engineering*. 2005. 36 (8): 597-608.
190. Alawar, Ahmad, Hamed Ahmad M. and Al-Kaabi Khalifa. Characterization of treated date palm tree fiber as composite reinforcement. *Composites Part B: Engineering*. 2009. 40 (7): 601-606.
191. Anderson, Mark J and Whitcomb Patrick J. RSM simplified: Optimizing processes using response surface methods for design of experiments. Productivity press. 2005.